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THE APPLICATION AND MEASUREMENT OF ARTIFICIAL RAINFALL ON THE TYPES FA AND F INFILTROMETERS

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FOREST SERVICE

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

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FOLDER 2 - APPENDICES

THE APPLICATION AND MEASUREMENT OF ARTIFICIAL RAINFALL ON THE TYPES FA AND F INFILTROMETERS

By

H. G. Wilm, Lowell Woodward, and Bert C. Goodell

Fort Collins, Colorado

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APPENDIX A

DETAILED DESCRIPTION OF Rocky Mountain INFILTROMETER EQUIPMENT

Modified Type FA Infiltrometer

Pump.--Jaeger centrifugal pump capable of producing 35 lbs. pressure. (Same pump as originally purchased by Flood Control Survey for use with the Type F infiltrometer.) Pump equipped with 25' of 1½" suction hose and screen.

Circulating system.--1½" canvas discharge hose (50' length) between pump and surge tank. Surge tank about 5 gal. capacity with 1" pipe nipples and 1½"x1" reducer on intake for connection to canvas hose (Figs. 1 and 2). To the tank is attached a rubber hose, with 1" couplings with pipe threads (as much as needed to reach from surge tank to plot). The strainer originally recommended and furnished with Type FA infiltrometer is attached to this 1" delivery hose (Fig. 3), and to the valve assembly, consisting of a 3/4" globe valve and 3/4" globe, needle point valve each on separate parallel pipes which are connected on both sides of the valves by means of 3/4" 45° Y's (Fig. 3). For larger volumes of water the globe valve is opened, and for accurately adjusting pressure the needle valve is used.

A 10-foot section of 3/4" hose (with pipe threads) connects the valve assembly with the applicator.

Applicator.--A 3/4" applicator pipe which feeds three Type F nozzles is permanently mounted on an angle iron frame (Figs. 4 and 5). The frame has two points which fit against the plot side to set the nozzles 3" from the plot. When the frame is leveled from right to left (looking up the slope) the angle of the nozzles is 7° from vertical, pointing toward the plot. Each nozzle is mounted in a street-ell so that it can be rotated in a plane parallel to the long axis of the plot. Thus the nozzles may be set in a vertical position on a plot of any slope, so that each nozzle will throw its spray vertically in a plane parallel to the short axis of the plot, and at a 7° angle in the other plane. A pressure gage, of 0-30 lb. capacity and sensitive to 1/4 lb., is connected to the applicator pipe near its outside end, so that the pipe and gage may be extended through the wall of the windbreaker tent. The three nozzles are spaced 5.3 inches apart on the applicator pipe.

This applicator frame differs only in unessential details from the rougher model which was actually used in the experiments (cf. Fig. 1). For future use it is suggested that the nozzles be set 4 inches away from the plot, and tilted at an angle of 4° toward the plot. This arrangement more nearly centers the plot in the rainfall pattern.

Plot equipment.--The infiltrometer frame used in the experiments was 12x30 inches in plan dimensions, and 6 inches deep; 3 inches to be set below and 3 above the soil surface (Fig. 1).

For future use the following equipment is recommended instead:

The recommended frame is made in two pieces (Figs. 6 and 7; also see designs). One piece includes the side walls, end walls, and runoff collector trough; the other, covers and rain-cutting edges for each end of the plot, a swinging splash shield, and trough rain-gages on each side. The covers and trough gages are mounted together on an angle-iron frame, so that the whole upper unit may be moved up or down on the lower frame, to a position varying with the slope of the plot. On a 50 percent slope it is moved uphill as far as possible (Fig. 8), while on level ground it is pushed as far as possible in the other direction. This allows rain to hit the whole plot on any slope and prevents water from dropping directly into the collecting trough on the steeper slopes. The dimensions of the plot are $30\frac{1}{2}$"x12". The trough gages are 1" by $30\frac{1}{2}$" in dimensions, and 3" deep; they are mounted with their inside edges 1/4" away from the sides of the plot frame. To prevent rainfall from splashing from the soil directly into the runoff trough, a shield of light sheet iron is hung from the upper member (hood) so that it pivots freely. At any slope, this screen hangs directly above the collector-trough lip and almost completely closes the aperture (Figs. 6 and 8). For inspection of the runoff trough, the screen is easily tilted inward by hand and swings back in place when released.

Rainfall and runoff are measured in cc.; on gentle slopes, 1 cc. of runoff per minute equals a rate of 0.01 inch per hour.

Accessory equipment used in experiments.--

Rainfall pans. Two types of pan were used in these studies, one $1\frac{1}{2}$" deep and the 3" deep, and both 12x30" in size. Before each test the exact area of each pan was obtained by 15 measurements of width and 6 of length. These pans were tested with and without splash protection by means of baffles or window screen. The screen employed in both pans was of 14-mesh galvanized wire, supported $\frac{1}{2}$ inch above the floor of the pan (Fig. 9). The baffle grid used in the 3" pan was made of five 3" strips of 24-gauge galvanized iron, spaced 2 inches apart, with the end and side walls 2 inches from the sides of the pan (Fig. 9). In the $1\frac{1}{2}$" pan, a similar grid was made of strips $1\frac{1}{2}$" wide. The outside strips on each side were 1" from the pan wall; the next strips 1" from the first ones; and the remaining strips were 2" apart (Fig. 10). The best protection for the $1\frac{1}{2}$" pan was found to be the baffle grid, cut down to 1" in height and placed over the screen (Fig. 10).

Rain cans. For preliminary pattern tests and selection of nozzles, 24 cylindrical cans were hung on a frame over the infiltrometer; each can was 0.992" in diameter and 4" deep. In tests of these rain-cans for the measurement of applied rainfall, 10 cans were hung on a frame so that each can was in the center of a 6" square (Figs. 11 and 12). The frame itself, made of $\frac{1}{2}$" angle iron, was 13" wide and 32" long (inside) so that it hung $\frac{1}{2}$" outside the side walls and 1" outside the ends of the infiltrometer.

Trough gages. These gages were 1" wide, 30" long, and 3" deep; they were set with their inside edges about 3/4" away from the side walls of the infiltrometer (Fig. 1). Before the tests, the area of each gage was obtained by 15 caliper measurements of width and 2 of length.

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Fig. 1.--General view of Type FA infiltrometer on 5 percent slope, with sprinklers 30" above plot, 3" away from it, and inclined 7° toward it. A line drawn through the tops of the sprinklers is parallel to the plot slope, but each nozzle is vertical in a plane normal to the long axis of the plot. Trough rain gages 1"x30" in dimensions and 3" deep are mounted 3/4" away from each side of the instrument. A pan 3" deep and protected with window screen ½" above the floor of the pan is hung in the plot frame. Note surge tank and split valves.

Fig. 2.--Detailed view of surge tank, Type FA infiltrometer

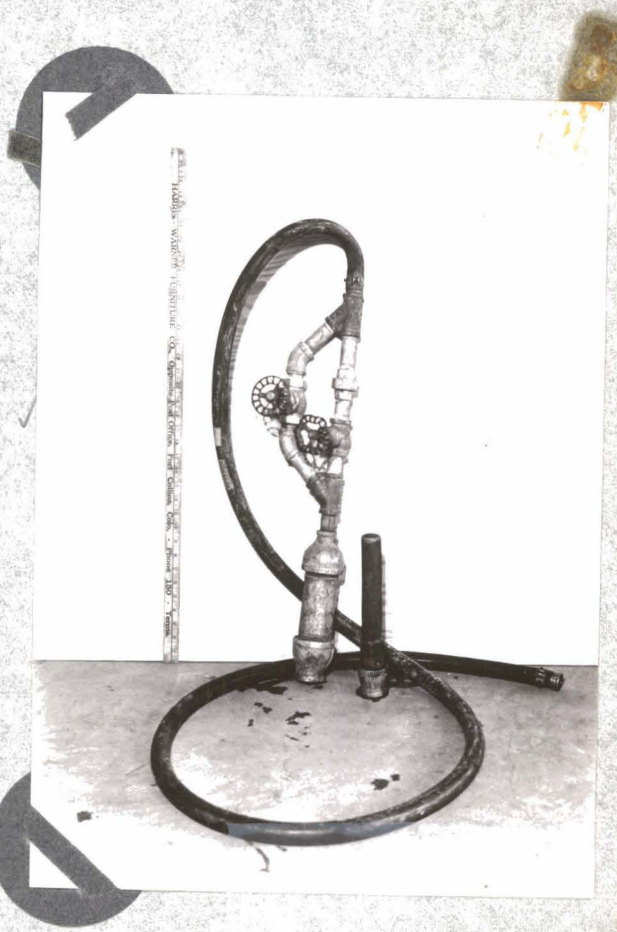


Fig. 3.--Type FA infiltrometer - double valve and strainer with screen removed. Needle valve at left; globe valve in straight pipe

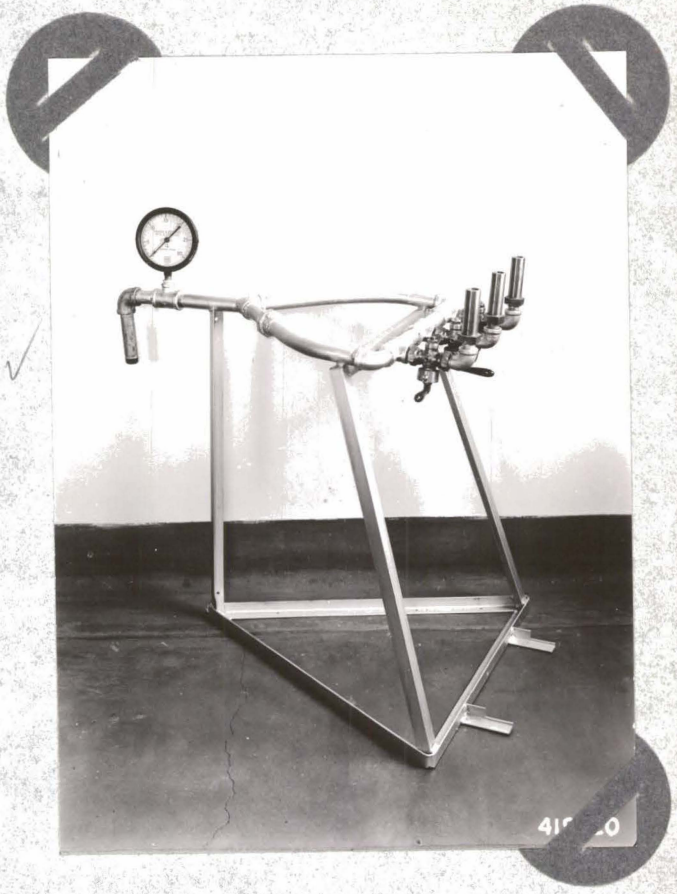


Fig. 4.--Applicator frame for Type FA infiltrometer. When the base is level from front to rear and the two front stubs are set against the plot frame, the nozzles are automatically in their proper position. Valves are provided for regulation of rainfall intensity by closing one or more nozzles.

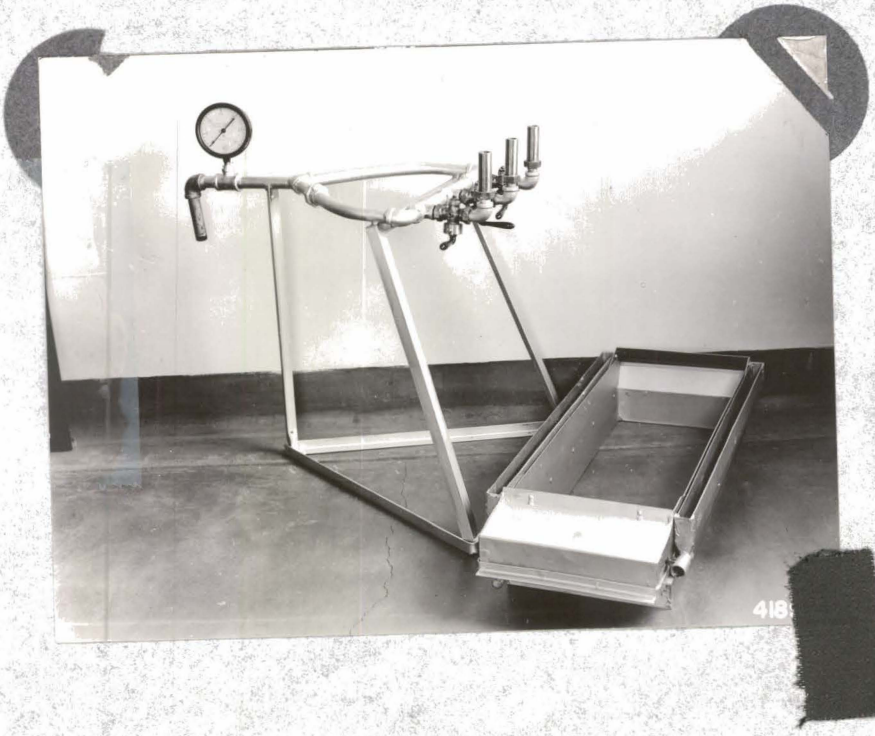


Fig. 5.--Applicator frame in operating position beside Type FA infiltrometer (new design).

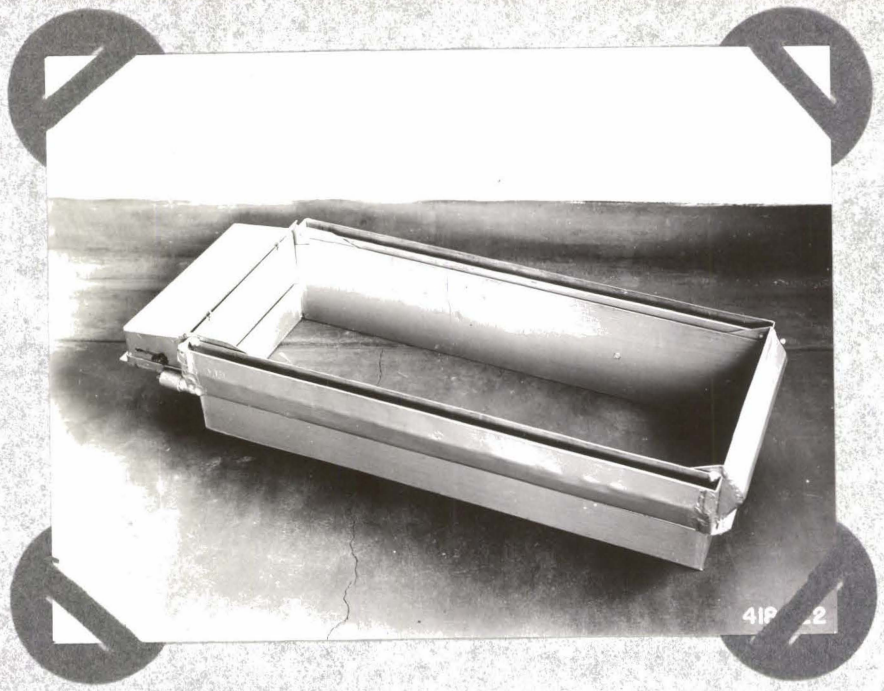


Fig. 6.--Type FA infiltrometer (new design), assembled. On level ground (shown), the upper member is moved as far as possible to the right, so that the rain-cutting edges at both ends are vertically above the ends of the plot and the sheet-metal shield almost closes the front opening of the runoff trough.

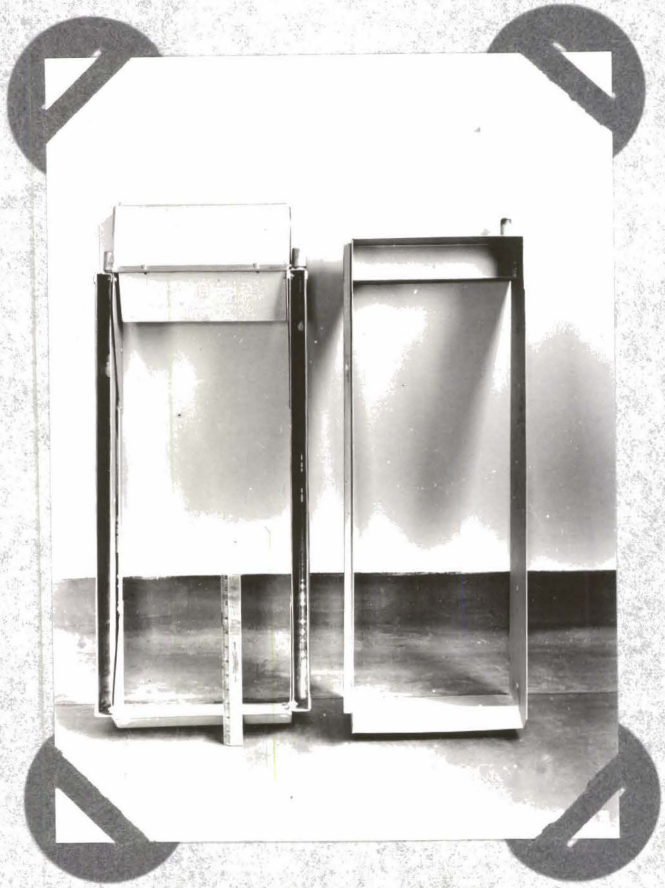


Fig. 7.--Type FA infiltrometer (new design), dismounted. Note trough gages attached to the upper (left) member.

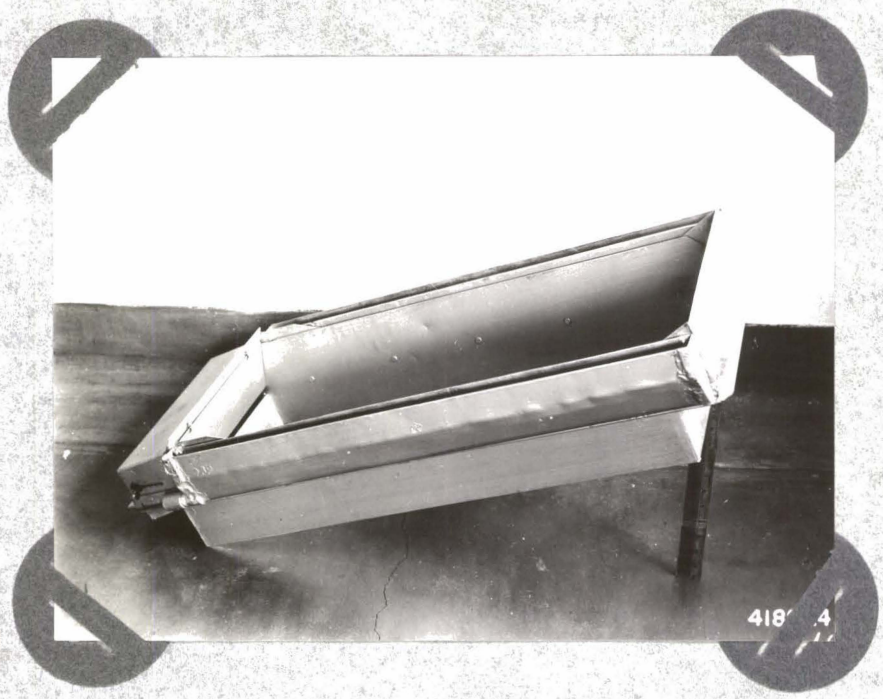


Fig. 8.--Type FA infiltrometer (new design) set on a slope of 50 percent. The upper member has been moved uphill (and locked by a wing-nut) so that the rain-cutting edges are vertically over the upper end of the plot and the lip of the runoff trough. The sheet-metal shield hangs directly over the lip of the collector trough.

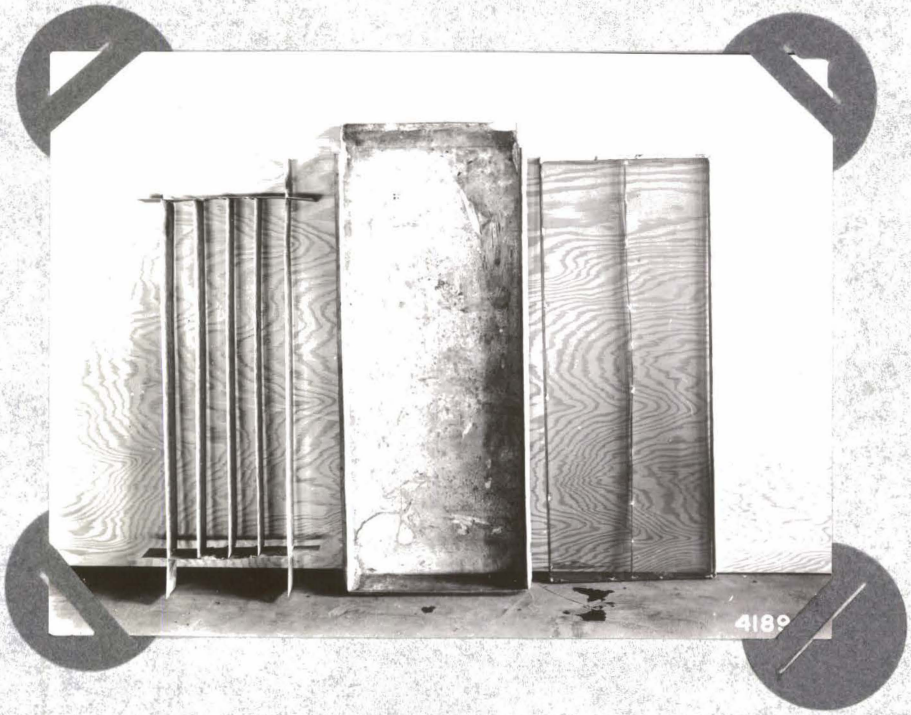


Fig. 9.--Three-inch pan used for catching rainfall applied to the Type FA infiltrometer, with baffle grid (left) and screen.

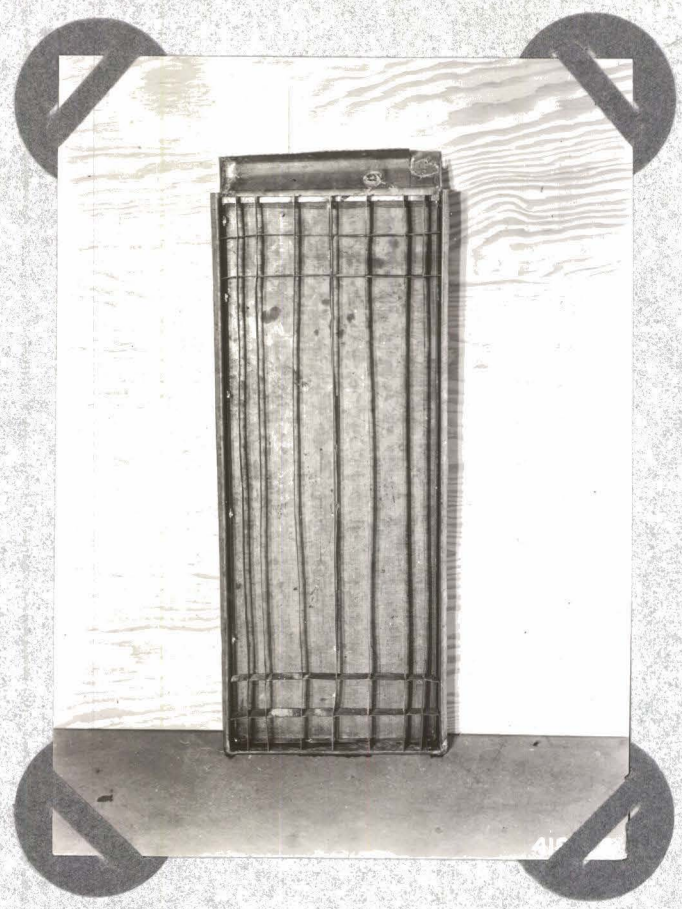


Fig. 10.--One and one-half inch pan used in Type FA infiltrometer, with screen and baffle grid installed.

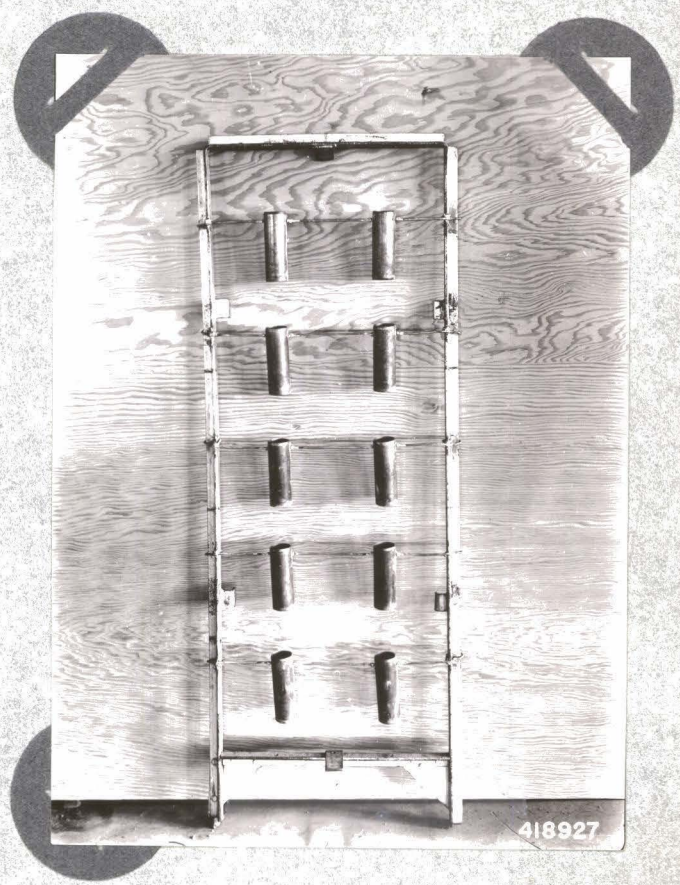


Fig. 11.--Rain-gage frame for Type FA infiltrometer.

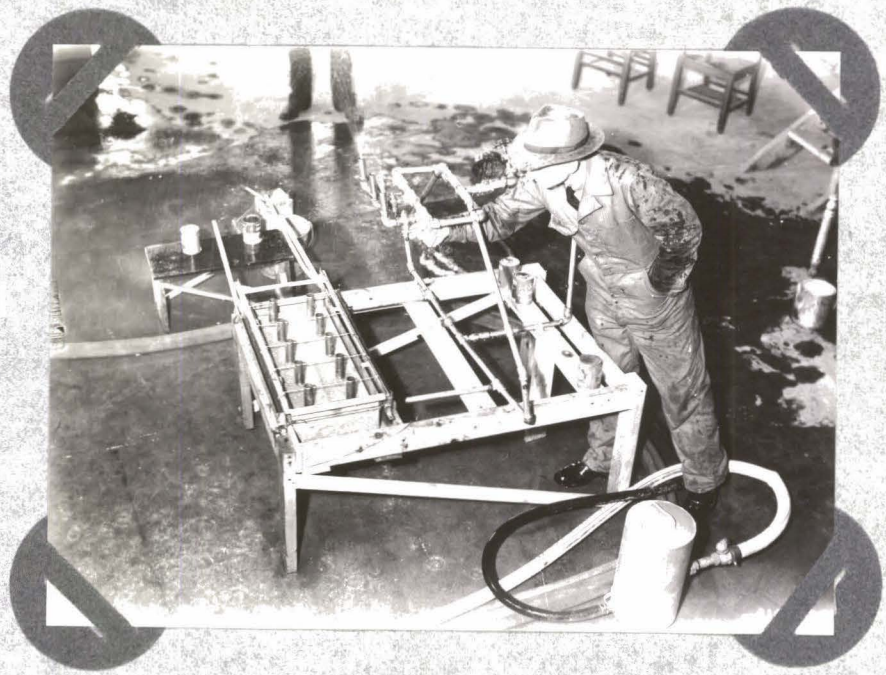
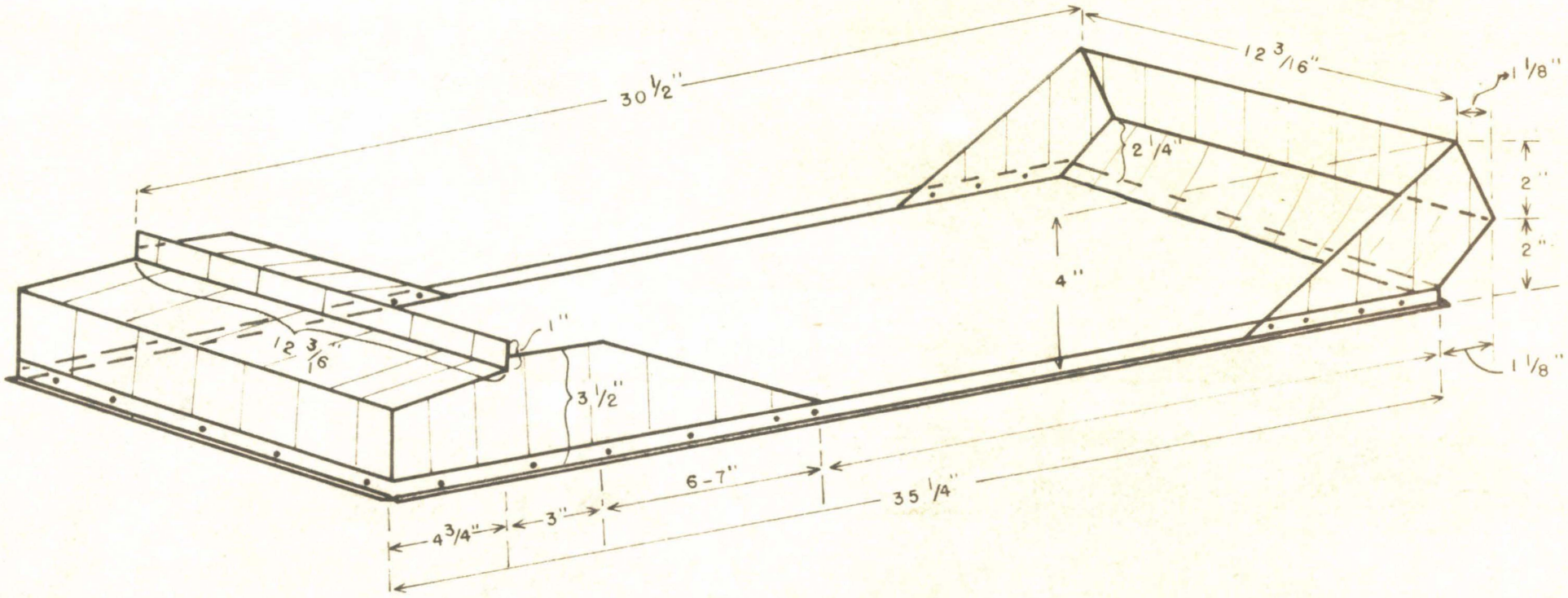


Fig. 12.--Type FA infiltrometer in operation, with ten 1-inch rain cans in place over 3-inch screened pan.

HOOD FOR REVISED TYPE FA INFILTROMETER



RIVET TROUGH GAGES TO SIDES, WITH LOWER END OF GAGE OPPOSITE LOWER CUTTING EDGE OF HOOD

Type F Infiltrometer

Pump.--Standard Pacific Marine Fire Pump (4 cylinder Austin motor, gear pump) or equal, complete with 10 to 25 feet of 1½" to 2" suction hose with screen on intake end. (Jaeger pump furnished with Type F infiltrometer was not capable of producing and maintaining sufficiently constant pressure). Pump should be able to produce 100 lbs. pressure and should deliver 15 gal. of water per minute to 60 lbs. pressure.

Circulating system.--Where a gear pump of high capacity is used and few nozzles are turned on a 1½"x1"x1" reducing T is connected to the pump (Fig. 13). A 1" globe valve is connected to the side and a 1" hose is connected to the end of the reducing tee. By adjusting the globe valve on the "by-pass" water can be recirculated to the source of supply and the pump can run at sufficient speed to maintain constant pressure. Rubber hose with 1" pipe thread couplings carries the water through the surge tank to the plot. Near the plot, the 1" hose is connected to a 1" globe valve which is used for adjusting the pressure in the applicator. A 1"x1½" bushing connects the nipple on the globe valve with a 1½" union which is connected to the strainer furnished for use on the Type F instrument. A 1"x1"x1½" reducing tee is connected to the 1½" fittings on the strainer. The male ends of two 25-foot lengths of 1" hose are connected to the 1" openings of the reducing tee and the female ends are connected to the up-hill ends of the applicator pipes.

Applicator.--The Type F applicator has been modified in the following respects from those originally specified (Fig. 14). Each applicator pipe feeds 13 Type F nozzles, spaced 15 inches apart. The nozzles are mounted on tees, welded to the main feed pipe; the feed pipe is welded to its angle-iron support so that all nozzles will slope toward the plot at an angle of 7° when the applicator is installed over the plot. Between each nozzle and the applicator pipe is a ½" brass cock (Figs. 15 and 16; see also designs) for rapid changes of rainfall intensity during determinations. A new type hood slides on tracks to cover the nozzles. The entire applicator is mounted on a frame which clamps into position over the plot and is supported by folding legs (Fig. 15) which can be lengthened or shortened to permit the setting of the applicator parallel to the slope. The leg is constructed in such a way that the adjustable part cannot fall out while applicator is being moved. The 0 to 60 lb. pressure gages furnished with Type F infiltrometers are satisfactory for indicating water pressure.

Plot equipment.--Plot sides and ends are the same as originally sent with the Type F infiltrometer. The collecting trough, however, has been modified for use in weighing runoff (Fig. 17 and 18; also designs). A drain pipe can be moved back and forth to allow runoff water to go into either of two collecting buckets (Fig. 19). The runoff caught in each bucket is measured by weight, on a springless balance accurate to 1/10th pound.

In these experiments the infiltrometer frame (simulated by sharpened 1"x4" boards) was mounted on a wooden table 8'x14' in size, which was constructed so that it could be tilted to three slopes: 5, 20, and 30 percent (Figs. 14 and 20). The plot boundaries were set 1' in from the sides and 2' down from the uphill end of the table, so that splash from the outside could occur more or less naturally. The whole plot was covered with a waterproof canvas tarpaulin, draped so that it rested on the table within 6" to 8" of the plot boundaries, both inside and outside of the plot. The lower end of the canvas was carried directly into the collector trough. Collector cans and accessory equipment below the plot were protected from splash and direct rainfall by a tarpaulin hung vertically, about 1' downhill from the collector trough (Fig. 20).

Accessory equipment.--

Trough rain gages. In these experiments rainfall was measured in 5 trough rain-gages as well as in the standard waterproof tarpaulin (Fig. 20). Each gage was 1½" by 12' in plan, and 4" deep; its exact area was obtained before the tests by means of 32 caliper measurements of width and 2 of length. The top of each gage was held 4¼" above the plot frame. Gages #1 and #5 were placed 4" (to center) outside the long sides of the plot; #3 bisected the plot; and #2 and #4 bisected the longitudinal halves of the plot. Rainfall in these gages was caught in 2-quart cans and measured in cc. After measurement water caught in the 3 gages directly over the plot was poured into the bucket collecting runoff from the tarpaulin, before the latter was weighed. This procedure compensated automatically for the rainfall withheld from the tarpaulin by the gages.

Splash protection. In certain tests the tarpaulin was protected from splash losses by draping a 6½'x14' sheet of 12-mesh unbleached muslin over the whole infiltrometer; the cloth was supported about an inch above the canvas except near the center and at the plot edges (Fig. 21).

Since it is believed from these experiments that most of the splash losses occur over the lower end of the plot, it is possible that splash protection could be provided adequately in field use by hanging a light shield of sheet metal, about 1¼'x6' in size, just over the upper and lower ends of the plot. The upper shield should drain just outside, and the lower one just inside, the plot boundaries.

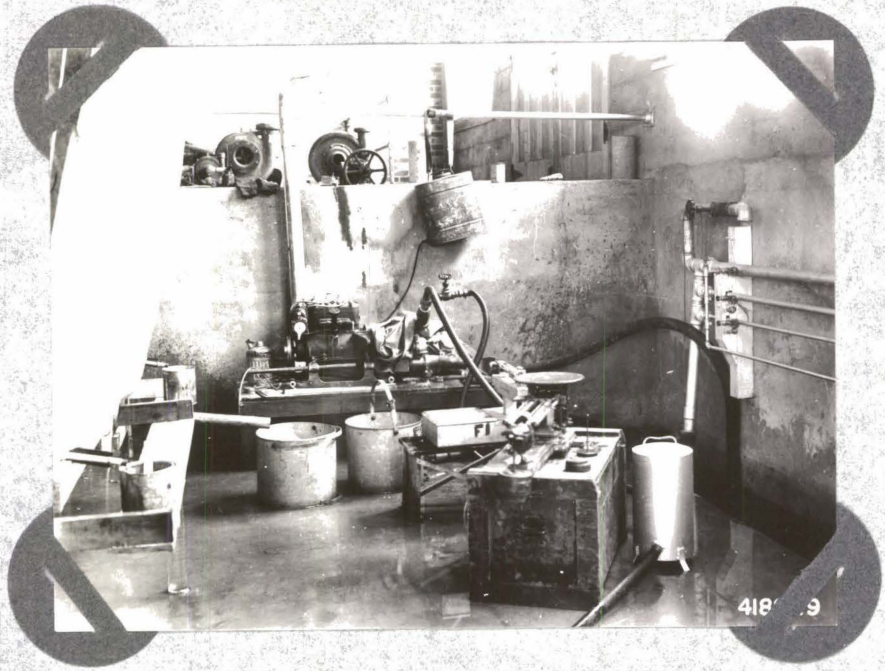


Fig. 13.--Pacific Marine pump supplies water to the Type F infiltrometer. Runoff is measured by weight.

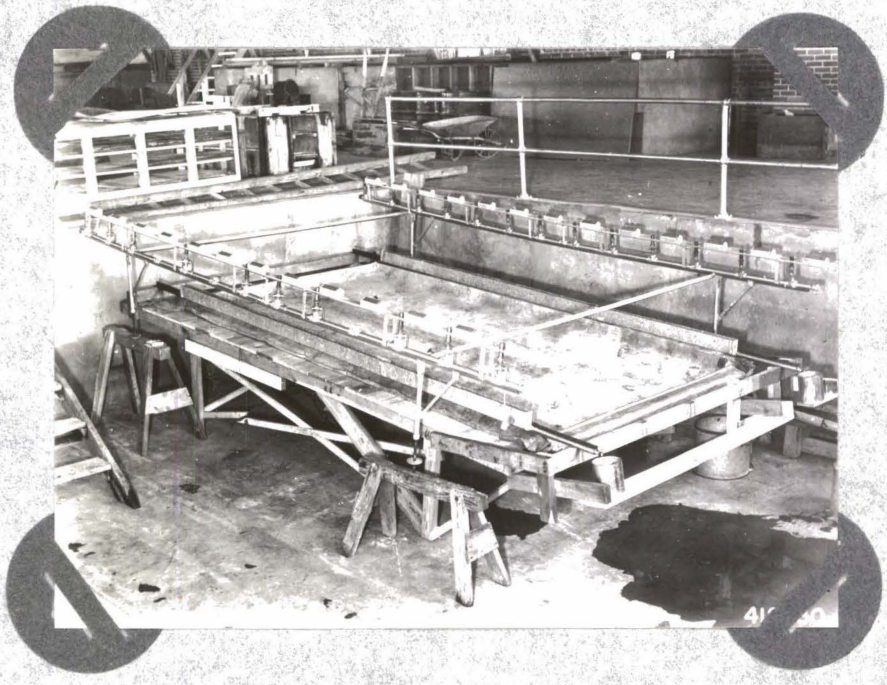


Fig. 14.--General view of Type F infiltrometer in the hydraulics laboratory, showing applicator frame in place. The plot, on a 5-percent slope, is covered with a waterproof canvas tarpaulin to catch rainfall.

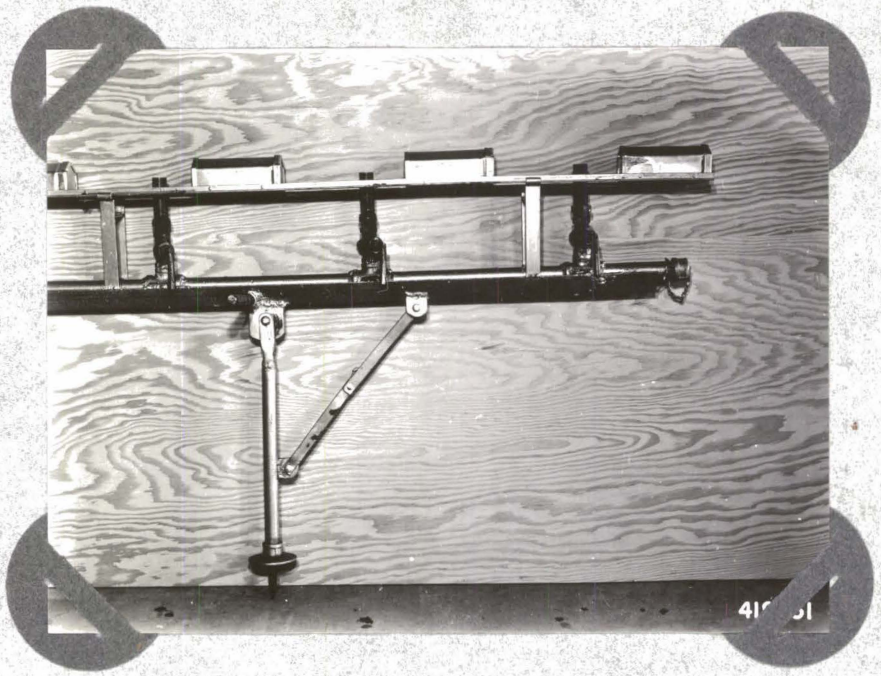


Fig. 15.--End of one applicator frame for Type F infiltrometer showing construction of leg and mounting of nozzles. "Designed by Intermountain Forest & Range Exp. Sta.)

Fig. 16.--Close-up of applicator frame for Type F infiltrometer, showing structure of nozzle hoods.

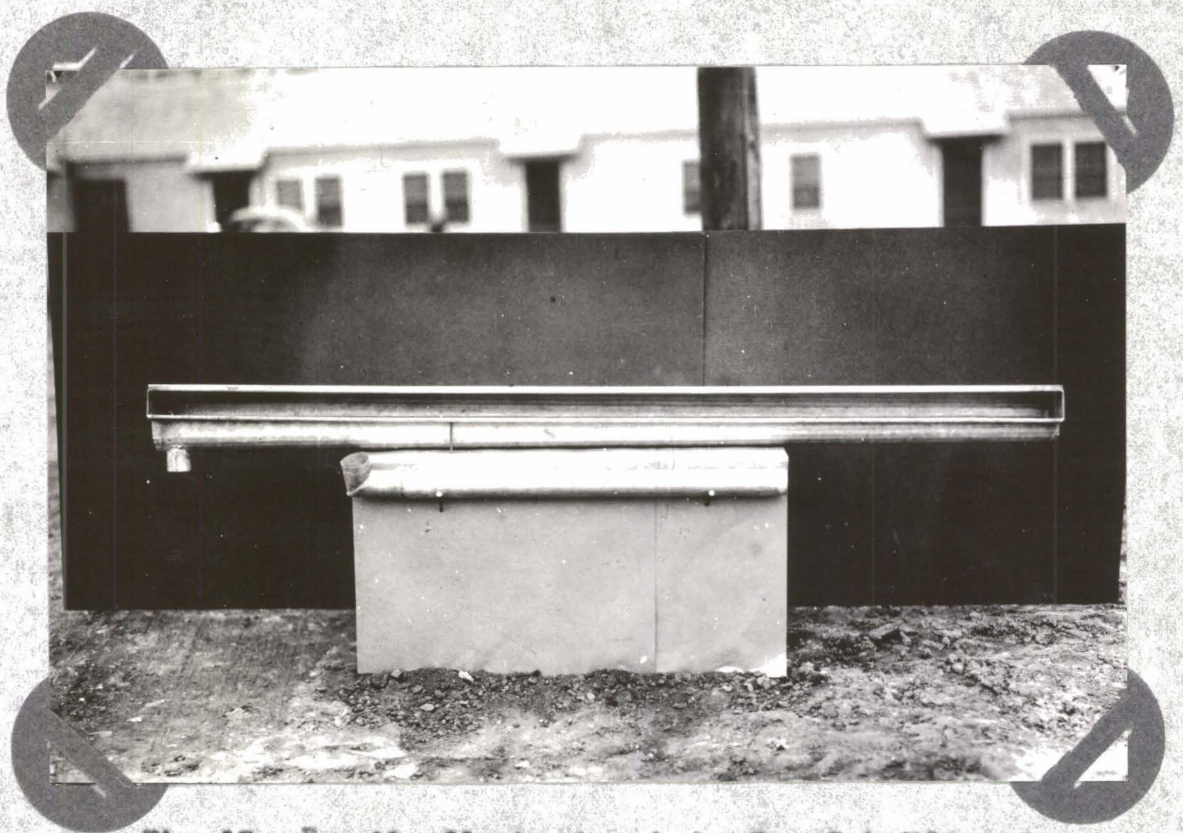


Fig. 17.--Runoff collector trough for Type F infiltrometer (designed by Intermountain Forest & Range Exp. Sta.)

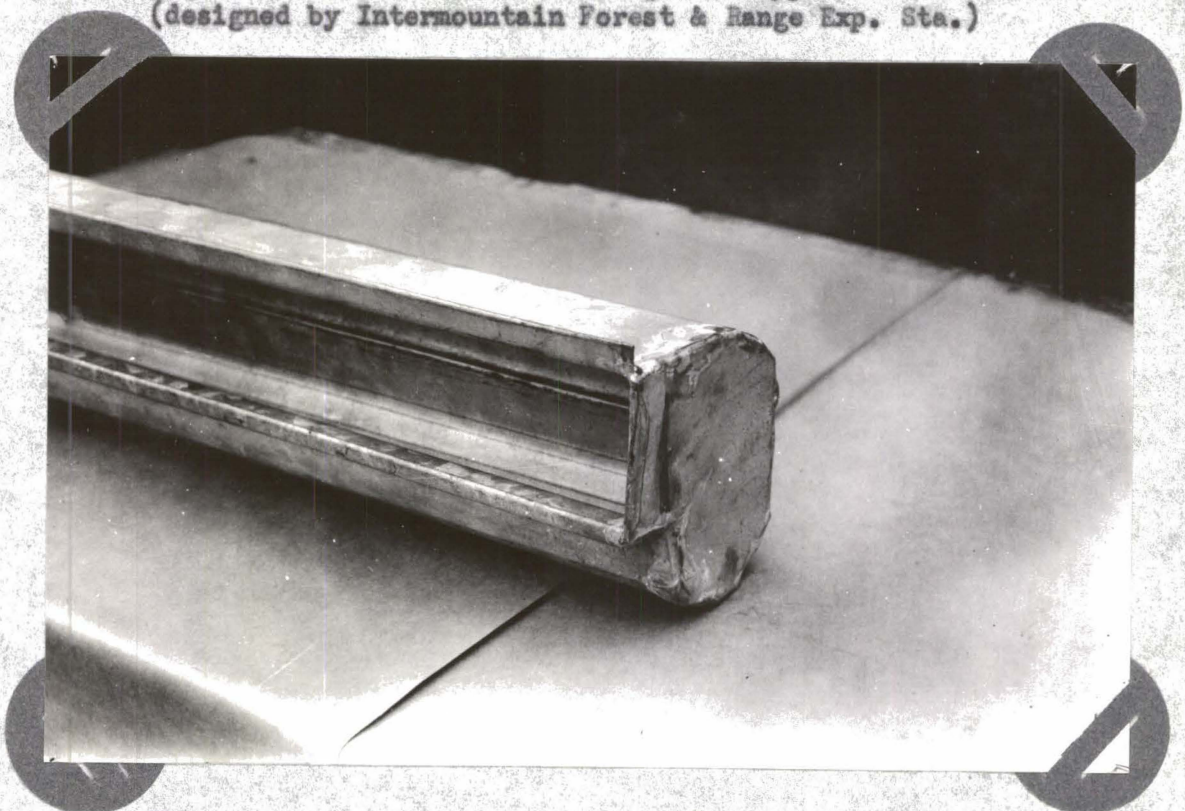


Fig. 18.--End detail of Type F collector trough.

Fig. 19.--Type F collector trough, showing drain pipe and buckets.

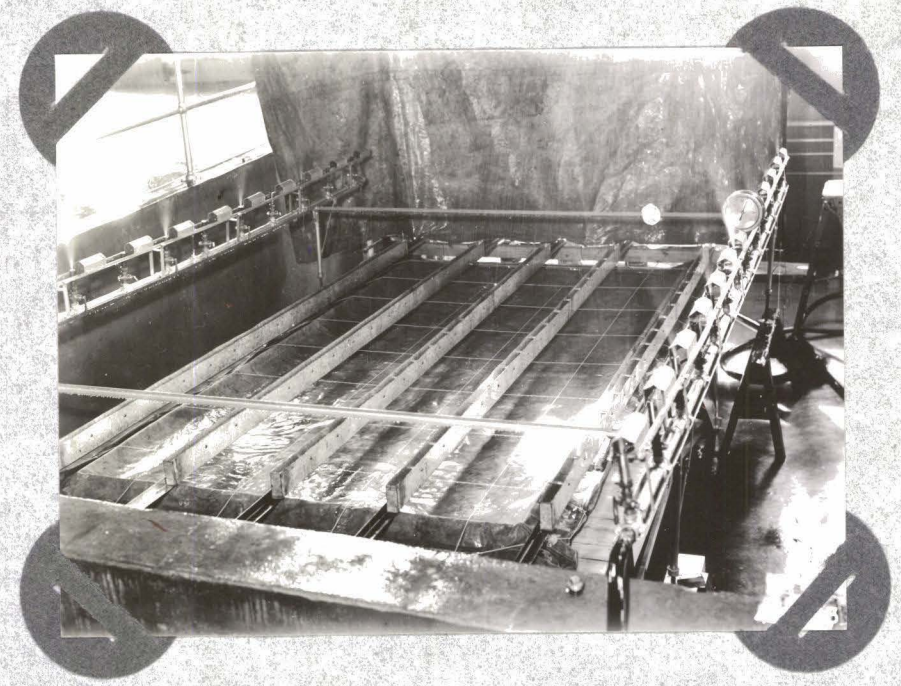


Fig. 20.--Type F infiltrometer in operation with 5 trough rain-gages in place.

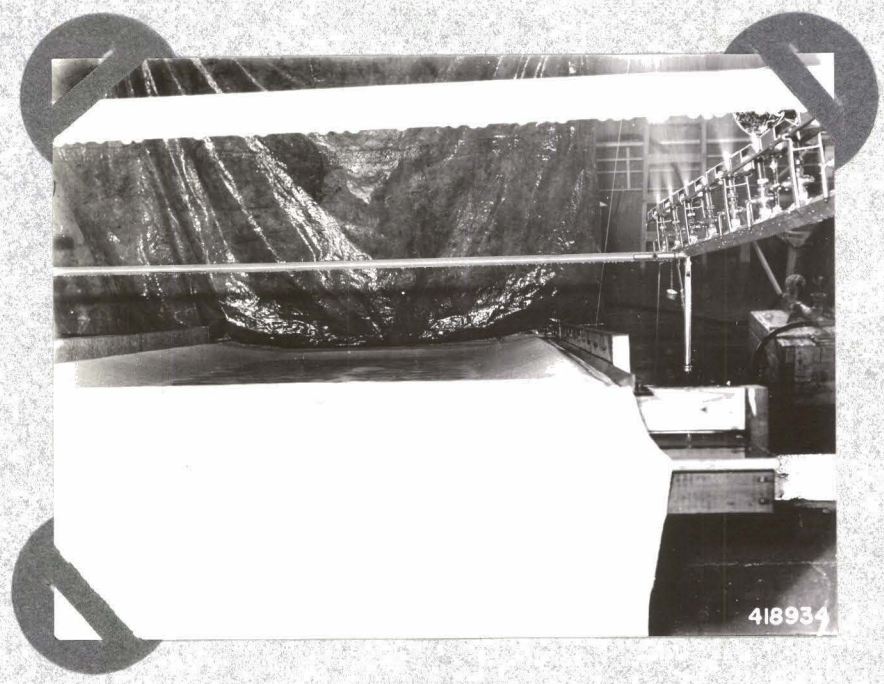


Fig. 21.--Type F infiltrometer, protected against splash losses by muslin cover.

APPENDIX B

SUMMARIES OF BASIC DATA, TYPE FA AND F INFILTROMETERS

The following tables summarize the original data employed in the variance analyses and related calculations shown in Tables 1 to 16. Each table of data is numbered to correspond to the tables of analysis; thus, Table 1a contains the data used in computing Table 1. In these tables, rainfall intensities described as "low," "medium," or "high" may be translated into terms of actual rainfall or number of nozzles employed by the following table:

Adjective	Approx. rate, in./hr.		No. nozzles	
	Type FA	Type F	Type FA	Type F
Low	2½	2	1	4
Medium	--	4	-	7
High	4½	6	2	10

Except when otherwise indicated, the plot was on a slope of 5 percent; the nozzles were tilted at a 7-degree angle toward the plot; and standard water pressures were used (Tape FA, 15 pounds; Type F, 35 pounds).

Table 1a.--Average rainfall caught in rain pans, Type FA infiltrometer

(Plot on 5% slope)

Pan	Rainfall intensity		
	Low	High	Sum
	In./hr.	In./hr.	In./hr
1½-inch			
Unprotected	2.15	3.15	5.30
Screened	2.46	4.08	6.54
Baffled	2.52	3.87	6.39
Sum	7.13	11.10	18.23
3-inch:			
Unprotected	2.30	3.60	5.90
Screened	2.52	4.03	6.55
Baffled	2.60	4.07	6.67
Sum	7.42	11.70	19.12

Each average is based on three observations, in a randomized-block design using 3 blocks.

Table 2a.--Comparison of rain pans: screened and baffled 1½-inch pan compared with 3-inch baffled pan (5% plot slope)

Basic data

Intensity	Trial No.	Pan record, inches/hr.	
		1½" pan	3" pan
Low	3	2.19	2.38
	4	2.27	2.21
	6	2.24	2.21
	8	2.24	2.23
Sum		8.94	9.03
High	1	4.79	4.64
	2	4.68	4.62
	5	4.72	4.57
	7	4.63	4.54
Sum		18.82	18.37
Grand Sum		27.76	27.40

This was a split-plot design; the two intensities were taken in random sequence, with paired observations of the two pans within each intensity trial.

Table 3a.--Basic data for comparison of 10-minute pan records before and after 1-hour runs, with true rainfall during each run.

Type FA infiltrometer

Series	Rain intensity	Interval - minutes									
		10	2	2	2	2	2	2	2	2	10
A	Low	2.49[1]	2.68	2.69	2.66	2.64	2.66	2.81	2.83	2.86	2.76
C	"	2.56	2.72	2.76	2.71	2.85	2.76	2.88	2.76	2.81	2.89
D	"	2.79	2.82	2.81	2.81	2.72	2.79	2.76	2.85	2.81	2.78
B	High	4.39	4.16	4.40	4.20	4.24	3.96	4.09	4.01	4.06	3.96
E	"	3.92	4.03	3.86	3.88	3.95	3.86	3.81	3.77	3.73	3.68
F	"	3.83	3.90	3.95	4.09	3.86	3.86	3.78	3.94	3.91	3.94

[1] Each pair of intervals separated by an interval of 5-6 minutes with no readings taken; the total length of each series was about 1½ hours. All data are in inches per hour. Six series of 10 readings were taken, with rainfall intensities in random sequence.

Table 5a.--Average rainfall caught in 10 1-inch rain cans, compared with rainfall in screened pan 3 inches deep.

Type FA infiltrometer

Series	Intensity	Rainfall, inches per hour		
		In pan	In rain cans	Difference
A	Low	2.70	3.22	+ 0.52
C	"	2.83	3.22	+ 0.39
D	"	2.79	3.04	+ 0.25
Sum		8.32	9.48	+ 1.16
B	High	4.13	4.60	+ 0.47
E	"	3.86	4.52	+ 0.66
F		3.93	4.38	+ 0.45
Sum		11.92	13.50	+ 1.58
Grand sum		20.24	22.98	+ 2.74

Each of the 12 averages is based on four observations. In each of the same 6 series of observations described in Table 3a, rain-cans were hung over the plot during 4 of the 8 2-minute observations.

Table 6a.--Average rainfall in two 1-inch and 30-inch trough rain-gages, compared with rainfall in screened 3-inch pan

Type FA infiltrometer

Series	Intensity	Rainfall, inches per hour		
		In pan	Trough	Difference
A	Low	2.75	2.72	- 0.03
C	"	2.74	2.70	- 0.04
D	"	2.80	2.79	- 0.01
Sum		8.29	8.21	- 0.08
B	High	4.15	4.15	0.00
E	"	3.86	3.92	+ 0.06
F	"	3.89	3.88	- 0.01
Sum		11.90	11.95	+ 0.05
Grand sum		20.19	20.16	- 0.03

Each of the 12 averages is based on 4 observations. In each of the same 6 series of observations described in Table 3a, trough-gage readings were taken in 4 of the 8 2-minute intervals. The other 4 intervals could not be used, as the rain-can frame was hung over the trough gages.

Table 7a.--Average rainfall in troughs and pan. Type FA infiltrometer

Plot slope 5 percent; pressure 14, 15, 16 lbs.; nozzles at 4° and 7° slopes

All data in inches per hour

Pressure	Nozzle slope						Sum		
	4°			7°					
	Pan	Troughs	Diff.	Pan	Troughs	Diff.	Pan	Troughs	Diff.
14#	4.93	4.79	-0.14	4.29	4.26	-0.03	9.22	9.05	-0.17
15#	4.69	4.61	-0.08	3.96	3.96	0.00	8.65	8.57	-0.08
16#	4.54	4.48	-0.06	3.91	3.85	-0.06	8.45	8.33	-0.12
Sum	14.16	13.88	-0.28	12.16	12.07	-0.09	26.32	25.95	-0.37

Each of the 12 averages is based on 4 observations. This was a split-plot study; pressure and nozzle slope were replicated in random sequence. Readings were taken with pan and trough gages for each 2-minute observation, at each pressure and nozzle slope.

Table 8a.--Final test of trough rain gages, Type FA infiltrometer

Plot slopes 5, 20, and 35 percent; nozzles at 4° angle

All data in inches per hour

Plot slope	Rain intensity: Low			Rain intensity: High			Sum		
	Pan	Trough	Diff.	Pan	Trough	Diff.	Pan	Trough	Diff.
%									
5	3.74	3.67	-0.07	4.48	4.43	-0.05	8.22	8.10	-0.12
20	3.78	3.64	-0.14	4.48	4.49	+0.01	8.26	8.13	-0.13
35	3.86	3.76	-0.10	4.32	4.34	+0.02	8.18	8.10	-0.08
Sum	11.38	11.07	-0.31	13.28	13.26	-0.02	24.66	24.33	-0.33

Each of these 12 averages is based on four 2-minute observations. This was a split-plot design, split twice. The major treatment (in this study the least important) was slope; each slope was tested twice, in random sequence. Within each slope test, each intensity was tested twice, in random sequence; and within each intensity test simultaneous readings were taken of rainfall in the pan and in the trough rain-gages.

Table 12a.--Basic data for comparing 10-minute tarpaulin records before and after 1-hour runs, with true rainfall during each run

Type F infiltrometer

All data in inches per hour

Plot slope	Rain intensity	Interval - minutes									
		10	2	2	2	2	2	2	2	2	10
%											
5	Low	2.15	2.15	2.11	2.12	2.11	2.10	2.09	2.11	2.12	2.11
	Medium	4.08	4.13	4.13	4.08	4.12	4.11	4.13	4.09	4.08	4.12
	High	5.81	5.70	5.70	5.65	5.81	5.69	5.70	5.74	5.72	5.63
20	Low	2.14	2.14	2.13	2.13	2.11	2.13	2.17	2.12	2.10	2.09
	Medium	4.04	4.15	3.99	4.02	3.98	4.04	4.14	4.07	4.22	4.00
	High	5.49	5.83	5.65	5.55	5.53	5.71	5.76	5.53	5.55	5.76
30	Low	2.07	2.03	2.03	2.02	2.03	2.00	2.01	2.01	2.00	1.99
	Medium	3.83	3.90	3.89	3.92	3.92	3.87	3.92	3.85	3.92	3.89
	High	5.54	5.58	5.54	5.58	5.52	5.54	5.56	5.53	5.61	5.52

This experiment was similar to the one described in Table 8a, except that three slopes and three rain intensities were included. Since slope and intensity were not replicated, no error terms are available for these factors. Both slope and intensity were, however, taken in random sequences so as to provide unbiased estimates of the interactions of "method" with slope and intensity.

Table 14a.--Average rainfall in trough gages, compared with rainfall on screened tarpaulin

Type F infiltrometer

Plot slope	Rain intensity	Rainfall, inches per hour, in: Tarp.	1 & 5 1/	Diff.	2 & 4 1/	Diff.	1,3,5 1/	Diff.
%								
5	Low	2.08	2.14	+0.06	2.16	+0.08	2.14	+0.06
	Medium	3.91	3.94	+0.03	4.04	+0.13	4.02	+0.11
	High	5.41	5.62	+0.21	5.58	+0.17	5.63	+0.22
Sum		11.40	11.70	+0.30	11.78	+0.38	11.79	+0.39
20	Low	2.06	2.20	+0.14	2.15	+0.09	2.19	+0.13
	Medium	3.81	3.84	+0.03	4.00	+0.19	3.97	+0.16
	High	5.38	5.53	+0.15	5.64	+0.26	5.66	+0.28
Sum		11.25	11.57	+0.32	11.79	+0.54	11.82	+0.57
30	Low	2.10	2.18	+0.08	2.23	+0.13	2.23	+0.13
	Medium	3.90	3.96	+0.06	4.19	+0.29	4.16	+0.26
	High	5.47	5.50	+0.03	5.86	+0.39	5.79	+0.32
Sum		11.47	11.64	+0.17	12.28	+0.81	12.18	+0.71
Grand sum		34.12	34.91	+0.79	35.85	+1.73	35.79	+1.67

1/ Average rainfall in gages 1 and 5; in gages 2 and 4; and in the three gages #1, 3, and 5. Conversion factors computed from these averages may disagree in the third place with those shown in Table 15, because of rounding the averages to two decimal places.

Each average is based on three 2-minute observations. The tarpaulin data above were also used in a part of the analysis in Table 16 ("Tarpaulin screened"). Again, this was a split-plot study, with "slope" as the "major treatment" (randomized, but not replicated). Within each slope test, each intensity was replicated three times at random; and simultaneous readings were taken of rainfall in the tarpaulin and all five trough gages after each intensity sample. In a similar study (data not shown), slopes were replicated; but since the tarpaulin was unscreened, the results could not be used for the comparison of troughs and tarpaulin. A variance for "within slopes" was derived from the unscreened study, however, and used in Table 16 for testing the variance between slopes.

APPENDIX C

RAINFALL PATTERNS

Type FA Infiltrometer

On the following page is a key to rainfall pattern data shown on the subsequent two pages for the Type FA infiltrometer. In each of these tests cans $3\frac{1}{4}$" in diameter and 4" high were placed in 7 rows of 4 cans, at the intersections of coordinates 6" apart on both axes. Thus 10 of the cans occupied most of the area covered by this type of infiltrometer, and these 10 cans were entirely surrounded by a single row of cans just outside the infiltrometer area.

In each of the 20 tests the platform supporting the cans was set at a slope of 5 percent, and readings were taken in cc. for a 4-minute interval. If it should be desired to convert these data per can to inches per hour, the conversion factor is:

$$\text{in/hour} = \text{cc.} \times 0.11048.$$

Each of the conditions tested was run in duplicate, to show the variation in pattern which may be expected even within a short period of time (about 12 minutes), with all conditions held as constant as possible.

The first three pairs of tests were made to try a new nozzle arrangement, with the tops of the nozzles 12" above and 6" away from nearest edge of the instrument; the line pressure was 20 pounds. Of these tests, #5 and #6 show the change in pattern which may occur when a nozzle is rotated 1/2 turn between runs. Tests #7 to #12 were made for comparison with the first 6 tests, with the nozzles 6" from the infiltrometer but 30" above it. #13 to #16 are patterns obtained with the standard position of sprinklers, 30" above and 3" away from the instrument and using a pressure of 15 pounds. In #17 to #20 the elevations of the nozzles was 30 inches, but their distance was 4 inches and their slope 4 degrees toward the plot instead of 7 degrees.

On the fourth page of Appendix C are shown a series of rainfall patterns taken from watershed infiltration studies at the Manitou Experimental Forest (1941). Rain-gage readings are given for 9 plots taken at random from all plots with slopes approximating 5, 20, and 30 percent in slope. For each plot, the data are in cc. for the last 10-minute period of a 50-minute infiltration run, recorded in 8 cylindrical rain-gages (each 0.992 inch in area) spaced evenly over the infiltrometer.

RAIN PATTERNS, TYPE FA INFILTROMETER

Description of each run - all runs 4 minutes - amounts in cc.

Run No.	Distance from frame to nozzle	Distance of nozzles above frame	Pitch of nozzle	Slope of frame and nozzles	Pressure	Number of nozzles turned on
	Inches	Inches	Degrees	Percent	Pounds	
1	6	12	7	5	20	2
2	"	"	"	"	"	2
3	"	"	"	"	"	1
4	"	"	"	"	"	1
5	"	"	"	"	"	1→ turn on nozzle, changing pattern
6	"	"	"	"	"	1→ " "
7	"	30	"	"	15	1→ " "
8	"	"	"	"	"	1→ " "
9	"	"	"	"	"	1
10	"	"	"	"	"	1
11	"	"	"	"	"	2
12	"	"	"	"	"	2
13	3	"	"	"	"	2
14	"	"	"	"	"	2
15	"	"	"	"	"	1
16	"	"	"	"	"	1
17	4	"	4	"	"	2
18	"	"	"	"	"	2
19	"	"	"	"	"	1
20	"	"	"	"	"	1

RAIN PATTERN TEST RUNS, TYPE FA INFILTROMETER

4 min. runs; all data in cc.

Run No. 1

33	39	36	38
37	41	44	40
39	61	55	42
68	122	102	47
54	141	99	44
42	69	50	35
26	28	28	25

Run No. 2

33	38	37	37
40	42	43	40
36	58	55	41
66	129	100	46
57	137	102	44
44	53	53	35
25	29	29	26

Run No. 3

7	9	11	13
10	12	14	16
12	14	18	21
11	15	21	27
15	19	25	32
18	23	30	37
16	23	29	38

Run No. 4

7	9	11	13
10	13	14	17
11	16	17	23
14	18	21	30
18	19	27	33
19	21	29	36
16	23	30	36

Run No. 5

37	34	25	18
50	43	27	19
51	40	28	20
49	42	25	18
47	37	27	17
38	31	27	19
22	24	20	13

Run No. 6

35	40	28	18
55	46	31	22
52	42	31	20
45	40	26	19
44	35	26	17
32	27	21	15
18	17	15	10

Run No. 9

10	14	15	16
13	20	24	28
21	24	36	39
17	35	42	48
25	32	42	45
23	29	38	41
14	23	26	30

Run No. 10

5	11	13	15
9	14	20	26
13	17	24	35
10	20	28	40
15	21	31	42
13	21	29	40
11	19	25	30

Run No. 7

27	53	31	22
50	47	38	27
58	54	43	27
47	51	40	28
48	41	31	22
30	33	22	17
16	20	15	13

Run No. 8

23	28	24	19
48	44	36	27
60	56	42	28
46	48	41	28
45	42	35	25
29	30	26	22
15	18	18	14

Run No. 11

38	31	36	33
51	51	43	38
57	51	43	35
55	50	40	38
55	46	40	34
45	40	37	34
37	35	32	28

Run No. 12

42	41	39	34
53	52	41	37
57	53	46	38
57	55	47	37
51	55	46	39
50	43	41	38
39	33	31	25

2N

Run No. 13

33	38	37	34
52	53	49	40
53	51	48	41
62	57	50	42
43	58	53	39
47	48	46	39
37	35	36	30

2N

Run No. 14

30	37	35	33
50	46	44	42
45	57	47	41
50	58	47	40
45	65	54	41
46	48	44	38
37	34	32	31

Run No. 15

5	8	11	14
8	13	18	25
10	15	22	31
12	17	25	36
12	20	26	38
11	20	29	39
9	15	27	32

Run No. 16

4	8	14	16
9	14	19	25
9	18	24	33
13	19	30	38
14	20	31	40
11	21	28	38
10	14	23	29

2N

Run No. 17

38	39	34	29
46	44	40	34
44	45	40	35
50	45	42	37
40	46	39	36
38	40	36	28
32	30	25	16

2N

Run No. 18

35	37	35	27
41	43	37	37
40	43	42	35
50	46	41	36
43	43	39	32
46	41	35	28
36	31	26	19

Run No. 19

14	18	19	16
21	28	32	28
22	36	43	43
22	39	48	50
25	41	47	53
20	35	42	41
19	26	26	26

Run No. 20

11	18	18	17
17	23	31	35
17	31	42	46
17	30	46	55
19	35	46	55
19	35	45	47
19	25	32	28

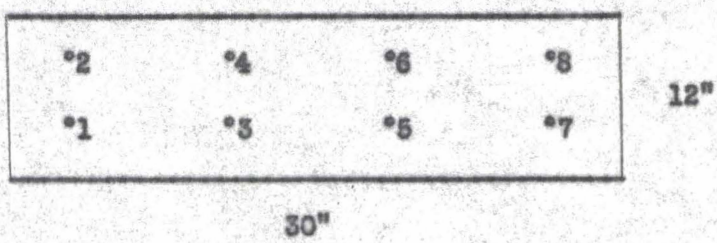
RAIN PATTERNS, TYPE FA INFILTROMETER

Influence of slope on pattern
(Manitou watershed data)

Each number is a 10-minute reading (interval 40-50 minutes). All data in cubic centimeters; intensity about 4 in./hr.

Watershed	Plot No.	Slope	Rain-gage number 1/							
		%	1	2	3	4	5	6	7	8
B	2-O-B-1	6	11.5	10.8	12.5	10.0	12.8	10.5	11.0	11.5
C	1-O-B-1	3.5	13.5	12.5	10.8	11.5	11.5	11.2	9.2	10.5
C	2-T-B-2	5	11.5	10.2	13.5	11.8	11.5	13.0	11.5	11.5
Sums			36.5	33.5	36.8	33.3	35.8	34.7	31.7	33.5
E	2-O-B-1	18	12.2	12.5	9.8	12.0	12.8	12.0	13.0	12.0
C	1-T-S-2	25	11.0	10.5	12.2	10.5	12.0	10.2	9.2	11.5
B	2-O-S-2	25	11.8	11.0	12.2	12.2	13.0	11.2	11.5	11.5
Sums			35.0	34.0	34.2	34.7	37.8	33.4	33.7	35.0
C	1-O-S-2	30.5	9.8	9.0	10.8	11.0	9.5	9.8	11.0	10.2
E	1-O-S-2	32.5	11.0	11.5	11.2	10.5	11.5	12.2	11.5	9.8
B	2-T-S-1	30.5	12.2	13.2	13.2	10.8	12.8	12.2	13.5	12.8
Sums			33.0	33.7	35.2	32.3	33.8	34.2	36.0	32.8

1/ Arrangement of gages:



Type F Infiltrometer

On the following pages are presented data on rainfall patterns obtained on the Type F infiltrometer at three slopes (5, 20, and 30 percent) and using three rates of rainfall application (about 2, 4, and 6 inches per hour). Using as origin a position in which the sprinkler frame would be centered over the plot on a slope of 0 percent, the frame was advanced 2½ inches uphill for each percent of plot slope; thus, on the 30 percent slope, the center of the frame was placed 75 inches uphill from the center of the plot. Otherwise all dimensions conformed to standard specifications.

For each of these patterns, rainfall was applied for 5 minutes and measured in 32 cylindrical cans, 3¼ inches in diameter and 4 inches high, placed normal to the plot in 8 rows of 4 cans. The rows and columns were 18 inches apart, with the outside rows and columns 9 inches inside the edges of the plot.

Thirteen nozzles were mounted on each side of the plot; for each intensity the following nozzles were left open (counting from the downhill end):

Intensity, about:	Nozzles open:
2 inches per hr. -	#1, 5, 9, 13
4 " " " -	1, 3, 5, 7, 9, 11, 13
6 " " " -	1, 2, 3, 5, 6, 8, 9, 11, 12, 13.

At each can position on each of the following patterns, two numbers are shown: these represent duplicate tests at the particular slope and intensity.

If it is desired to convert these data to rates in inches per hour, the conversion factors shown below should be used.

Slope, percent	Factor Inches per hour = cc. x :
5	0.08838
20	0.09003
30	0.09214

RAINFALL PATTERNS: TYPE F INFILTROMETER

Plot slope - 5 percent

30	27	28	31	45	50	47	35	69	69	75	74
34	29	31	32	43	44	47	40	70	75	84	75
39	34	29	29	58	58	55	45	87	89	85	77
43	35	28	27	58	57	42	43	81	94	91	80
29	26	22	20	60	65	57	46	85	87	78	67
28	28	21	19	56	63	55	42	74	84	82	70
28	24	25	24	55	57	59	51	64	63	62	56
28	23	23	23	54	54	54	45	56	62	71	62
27	26	34	31	51	54	58	54	54	60	64	59
26	24	34	31	54	59	60	52	54	61	68	61
19	27	33	34	43	52	63	59	54	67	83	82
19	30	32	34	52	60	63	63	54	58	73	77
22	24	28	30	42	50	59	58	55	67	93	97
25	28	28	33	47	55	47	59	57	66	87	96
32	30	28	34	46	46	51	52	62	73	89	89
32	29	28	31	50	49	52	46	67	64	77	81
Approx. intensity 2" per hour				Approx. intensity 4" per hour				Approx. intensity 6" per hour			

Plot slope - 20 percent

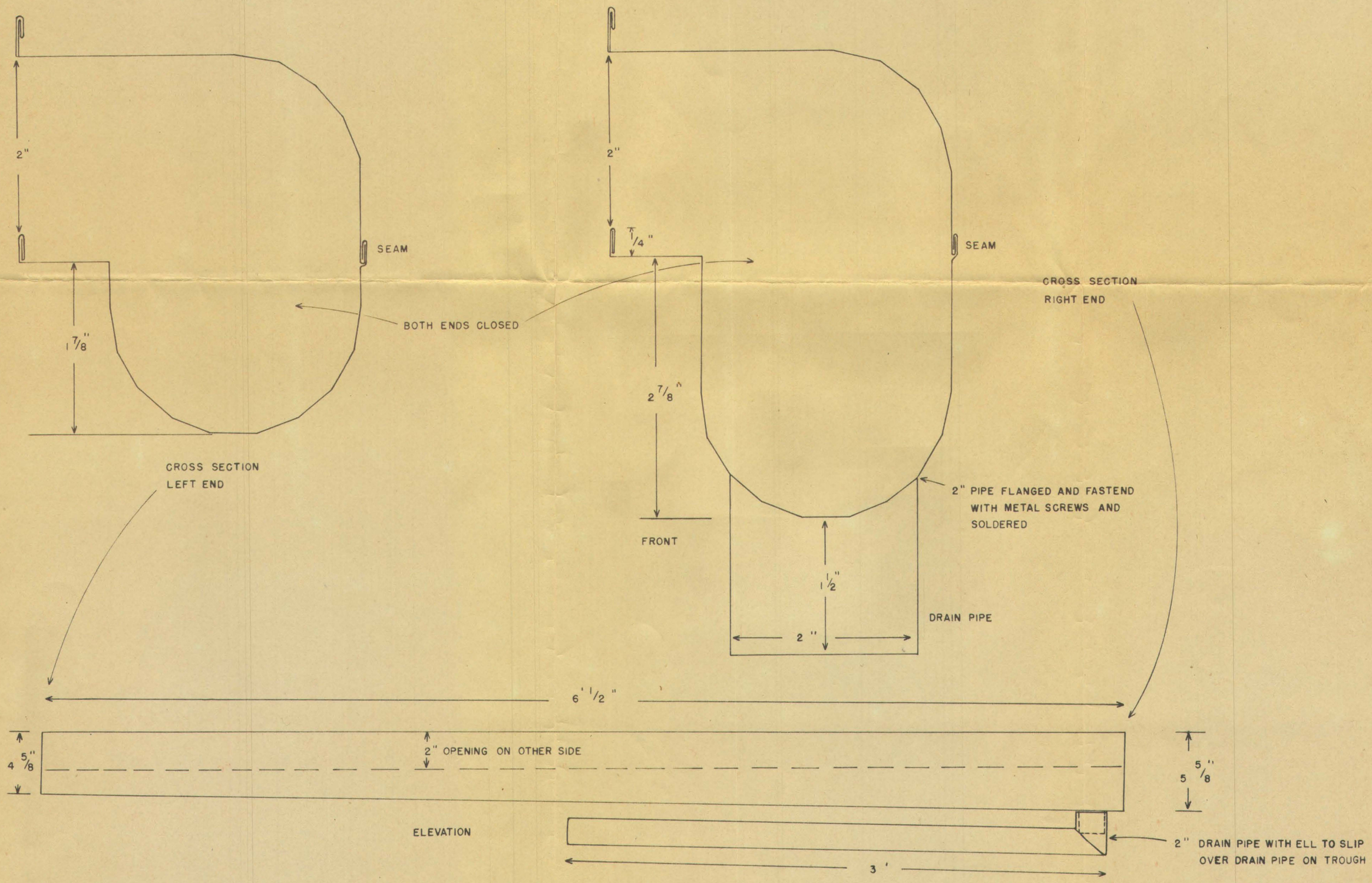
32	27	27	23	50	46	48	42	70	71	84	77
38	28	24	28	49	43	45	39	71	76	82	84
42	34	26	19	62	62	56	47	90	87	84	72
42	32	24	25	59	56	52	43	85	86	91	78
30	27	21	17	58	62	55	48	84	84	73	57
29	25	17	19	52	57	55	49	74	79	78	64
27	22	23	24	54	54	57	52	70	68	63	54
30	22	21	23	55	53	54	51	54	54	67	59
24	24	30	28	56	55	61	58	66	66	72	62
25	23	33	32	57	58	59	53	56	56	71	67
18	26	27	35	50	58	62	60	57	73	89	80
19	25	31	30	51	63	63	57	51	63	83	79
24	25	25	25	46	49	51	53	57	70	84	88
29	27	28	30	41	47	52	52	52	62	86	82
33	31	30	32	53	51	48	51	65	75	84	82
37	32	32	34	43	45	48	48	61	68	78	77
Approx. intensity 2" per hour				Approx. intensity 4" per hour				Approx. intensity 6" per hour			

RAINFALL PATTERNS; TYPE F INFILTROMETER

Plot slope - 30 percent

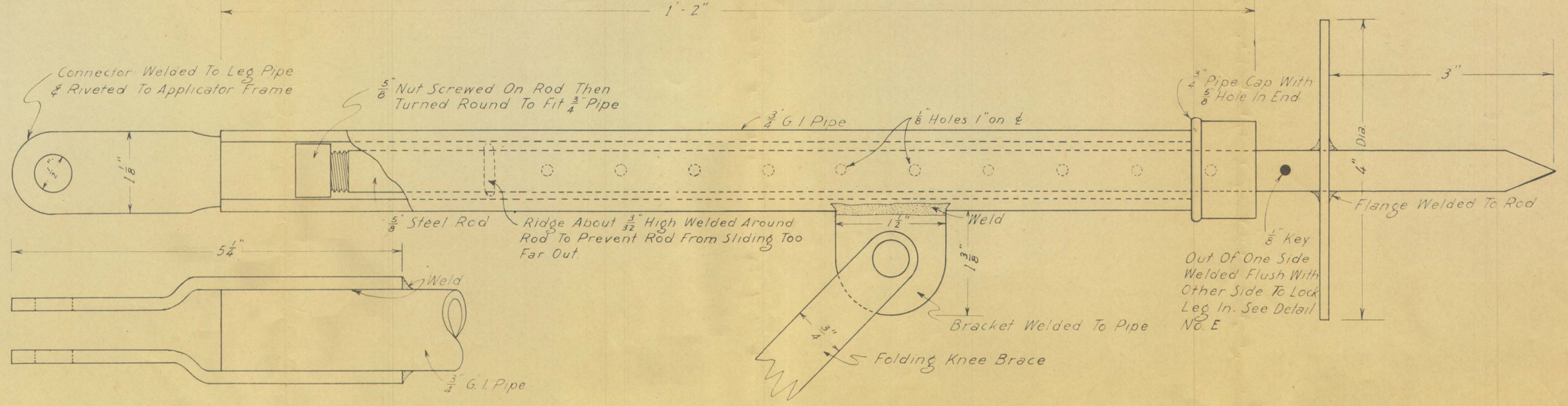
29	24	22	26	44	38	43	42	66	65	78	79
30	25	20	25	44	42	45	40	62	65	81	78
42	32	25	23	56	51	51	45	83	82	84	71
44	32	24	23	54	52	49	44	86	85	82	71
36	29	20	18	55	56	52	44	85	83	69	57
34	30	21	19	57	56	52	44	90	85	72	59
28	22	19	21	51	51	49	48	72	65	59	52
26	21	19	21	55	53	50	52	70	65	58	56
23	22	26	26	54	51	55	53	63	57	60	58
23	18	26	25	55	50	53	53	63	56	62	58
20	27	30	26	50	57	63	55	55	65	74	73
18	24	30	28	51	58	63	55	58	64	76	71
22	25	26	27	43	48	52	51	53	66	84	80
22	25	26	25	41	48	52	49	55	68	84	78
29	30	29	31	40	46	48	48	60	72	85	82
29	30	28	30	42	46	48	47	61	72	84	80
Approx. intensity 2" per hour				Approx. intensity 4" per hour				Approx. intensity 6" per hour			

TYPE F INFILTROMETER (REVISED) DETAILS OF RUNOFF COLLECTOR TROUGH

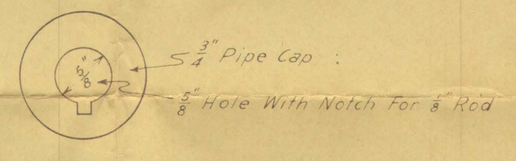


COLLECTING TROUGH — 20 Ga. GALV. STEEL

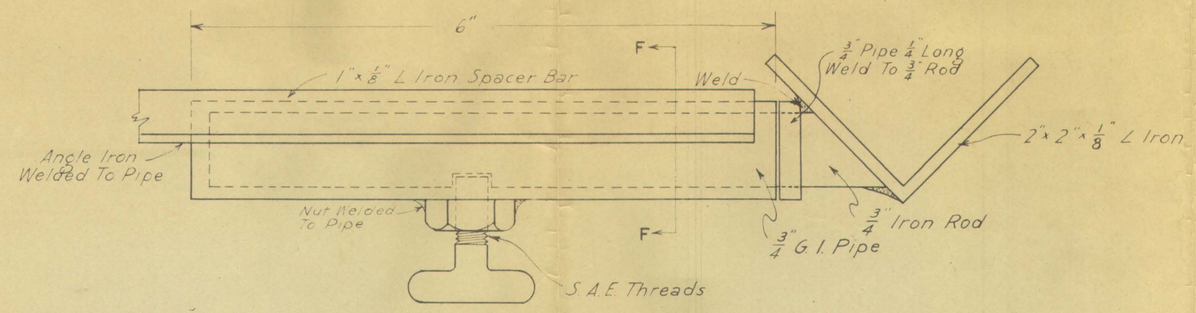
DESIGNED BY LOWELL WOODWARD


1'-2"
Connector Welded To Leg Pipe & Riveted To Applicator Frame
5/8" Nut Screwed On Rod Then Turned Round To Fit 3/4" Pipe
3/4" G.I Pipe
1/8" Holes 1" on ℄
3/4" Pipe Cap With 5/8" Hole In End
3"
Dia
4"
1'-10"
5/8" Steel Rod
Ridge About 3/32" High Welded Around Rod To Prevent Rod From Sliding Too Far Out
1 1/2"
Weld
Flange Welded To Rod
1/8" Key Out Of One Side Welded Flush With Other Side To Lock Leg In. See Detail No. E
5 1/4"
Weld
1 3/16"
Bracket Welded To Pipe
3/4"
Folding Knee Brace
3/4" G.I Pipe

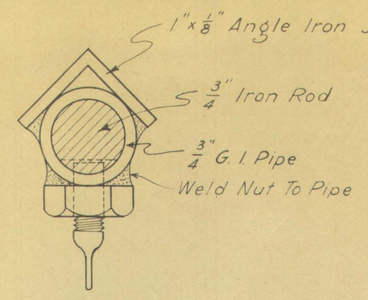
F. S. DETAIL D



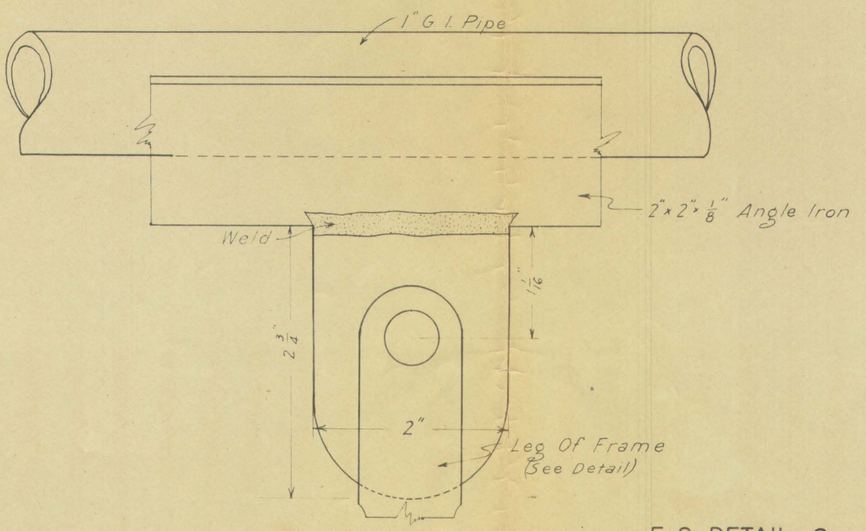
F. S. DETAIL E



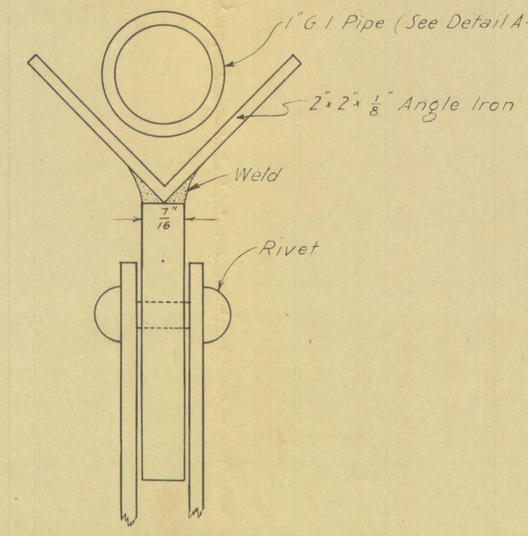
F. S. DETAIL B



SEC. F-F



F. S. DETAIL C

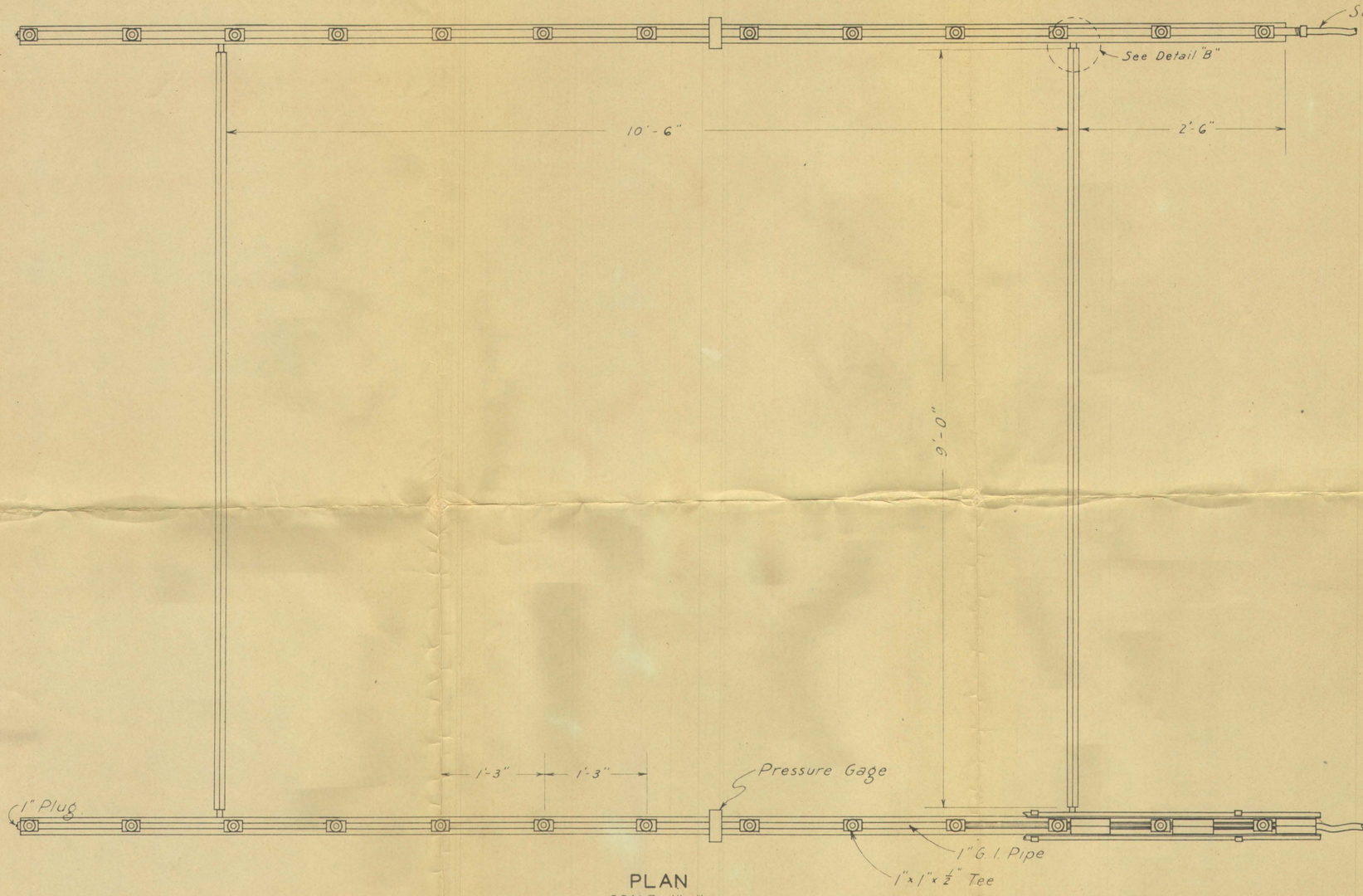


TYPE "F" INFILTROMETER

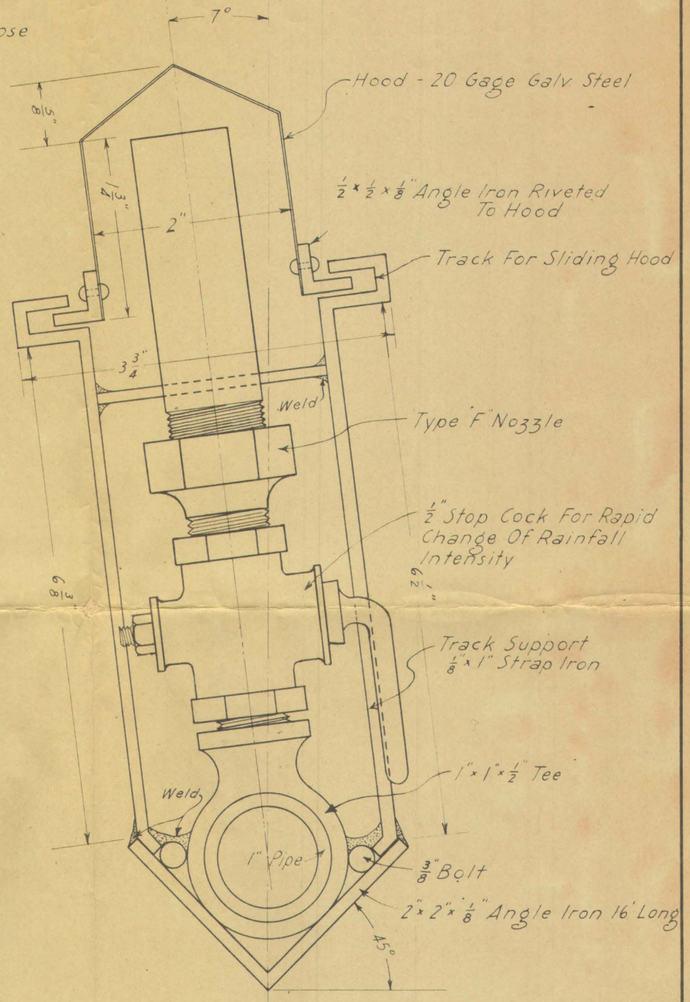
U. S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO. 761

PROJECT FLOOD CONTROL MAP NO 2

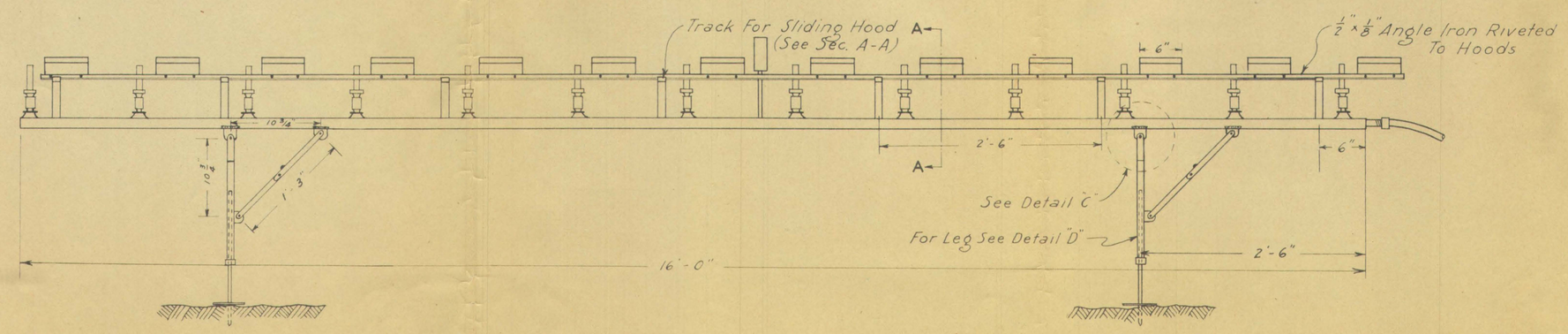
	NAME	BUREAU	DATE
DESIGNED BY	L. WOODWARD	FOREST SERVICE	4-15-41
TRACED BY	B. THURMOND	" "	2-23-42
APPROVED			



PLAN
SCALE 1"=1'



F. S.
SECTION A-A



SIDE VIEW
SCALE 1"=1'

TYPE "F" INFILTROMETER

U. S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO 761

PROJECT FLOOD CONTROL MAP NO. 1

	NAME	BUREAU	DATE
DESIGNED BY	L. WOODWARD	FOREST SERVICE	4-15-41
TRACED BY	B. THURMOND	" "	2-23-42
APPROVED			